Seasonal variation of airborne particles characteristics and sources in Beijing during 2010-2011

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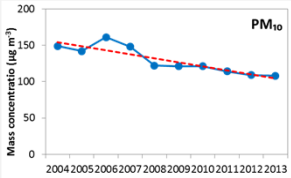
OBJECTIVES

Emission reduction measures were performed to improve air quality during the Olympic Summer Games in 2008: mainly PM_{10} reduced, haze became a problem (Du et al., 2014; Gao et al., 2014) - why?

Work program:

- Chemical composition of PM
- Characteristics of chemical composition
- Source apportionment



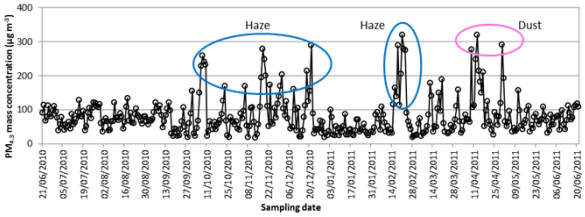
Source: Beijing environmental state report 2004-2013

METHODOLOGY

Particulate sampling on quartz fibre filters with 2 High-Volume Samplers DHA80 (Digitel) from June 2010 till June 2011 on the ground at the campus of the China University of Geosciences, Beijing (CUGB). Sampling time 24 hours. Backward trajectories with HYSPLIT4. Meteorological data: ZBAA (http://weather.uwyo.edu/upperair/sounding.html), IAP.

Particle composition: Inorganic elements by PEDXRF and $PM_{4.3}$ mass concentrations by filter weighing (sampler A). Inorganic water-soluble ions, EC / OC and organic speciation by IC with continuous flow analyzer, thermal/optical carbon analyzer and in situ derivatisation direct thermal desorption gas chromatography time-of-flight mass spectrometry (IDTD-GC-TOFMS), respectively (sampler B).

Source apportionment: Positive matrix factorization (PMF3.0, EPA).



Mass concentration from June 2010 till June 2011. Haze and dust periods marked.

RESULTS

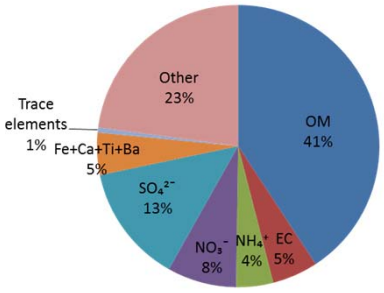
2010-2011 $PM_{4.3}$:
Annual average: 83 µg m^{-3}
Haze: 153 µg m^{-3}
Dust: 173 µg m^{-3}
Clear: 43 µg m^{-3}

PM characteristics:

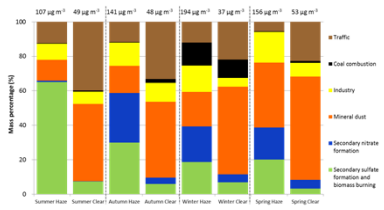
- Levoglucosan/OC → estimation of biomass burning contribution
- Hopane index: 30ab/(30ab+30ba) → vehicle exhaust emission or coal combustion source
  17α(H)21β(H)-Hopane/(17α(H)21β(H)-Hopane + 17β(H)21α(H)-Hopane)
- Homohopane index: 31abS/(31abS+31abR) → vehicle exhaust emission or coal combustion source
  22S-17α(H)21β(H)-Homohopane/(22S-17α(H)21β(H)-Homohopane + 22R-17α(H)21β(H)-Homohopane)
- BGH/BEP → vehicle exhaust emission source
  benz(g,h,i)perylene/benzo(e)pyrene
- IND/(IND+BGH) → vehicle exhaust emission or coal combustion source
  indeno(1,2,3,c,d) pyrene/(indeno(1,2,3,c,d) pyrene + benz(g,h,i)perylene)
- Mg/Al → dust source from inside or outside Beijing

Haze characteristics:

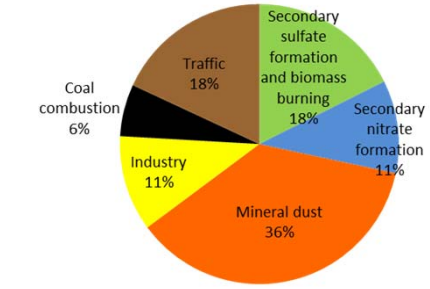
- Secondary inorganic ion concentrations increased
- High relative humidity, low mixing layer height
- Stagnant weather conditions with low air mass exchange



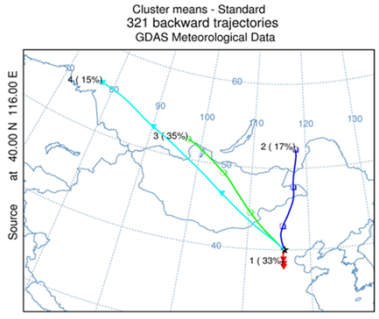
Mass balance of $PM_{4.3}$ compounds from June 2010 till June 2011.



Mass contribution of different sources to $PM_{4.3}$ during haze and clear days in different seasons from June 2010 till June 2011 determined from source apportionment and back trajectories cluster analysis.



Result of source apportionment by PMF from June 2010 till June 2011.



Cluster means of backward trajectories from June 2010 till June 2011.

PM emission sources:

Backward trajectories from the South, calculated for 72 hours in 500 m altitude at the target point, always short and with high PM mass concentrations (see figure):
Southerly pollution transports main source of haze particles in Beijing - industrial companies and big cities are in a distance of ~100 km (Liu et al., 2014).

Main sources of PM during haze are different from season to season:
- secondary inorganic ion formation and biomass burning for summer and autumn haze,
- coal combustion for winter haze and
- mineral dust emissions for spring haze.

Sources of PM during clear days were dominated by mineral dust emissions and traffic while haze was characterized by secondary inorganic ion formation during the whole year.

CONCLUSIONS

Haze more frequent because an increasing number of fine and anthropogenic particles is emitted.

Reduction of emissions of precursor gases of SO_4^{2-}, NO_3^- and NH_4^+ in the local and regional scale and thus of **road traffic emissions** necessary to decline haze periods.

Installation of **cleaning equipment in** industrial and mobile exhaust vents, **improvement of road cleaning standards** and reduction of construction dust emissions also important for improving air quality.

Further research on formation mechanisms and sources of haze episodes during different seasons in order to improve urban air quality.

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